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Detection of Solid C≡N Bearing Materials on Solar System Bodies

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The occurrence of solid matter of very low albedo on many small bodies of the Solar System is now widely acknowledged. To date a few hundred asteroids of very low albedo have been identified, and taxonomic schemes including subtypes defined by details of the spectral reflectance have been established. The surfaces of the nuclei of at least several comets are also of very low albedo. It is generally accepted, though not proven, that the cause of the low albedo of these bodies is the presence of macromolecular carbon-bearing compounds, elemental carbon, and opaque minerals. The dark asteroids are thought to be the source(s) of the carbonaceous meteorites, which contain complex organic solids of various kinds, elemental carbon, and organic-rich cosmic dust grains. Among the many low-albedo planetary satellites, the most striking example is the hemispheric covering on Saturn's satellite Iapetus which is centered on the apex of orbital motion (the "leading" hemisphere). The particles comprising the rings of Uranus appear to be similarly dark.

What, if anything, links chemically the meteorites, asteroids, comets, planetary rings and satellites, and possibly the interstellar medium, and what might this link tell us about the origins of the organic solids that they contain? In search of answers to this and related questions, we have pursued for several years a program of telescopic observations of small bodies in the Solar System.

In a new study we have found observational evidence for the presence of C≡N-bearing solid material on four classes of Solar System bodies: comets, asteroids, the rings of Uranus, and Saturn's satellite Iapetus. Gaseous CN has long been know in comet spectra, and the infrared spectra of Comet P/Halley obtained with the Vega spacecraft shows emission of the C≡N fundamental at 4.5 μm interpreted as solids containing the -C≡N group in the grains of the inner coma[15]. The data presented here offer the first evidence for chemically related material on the other objects.

We find a spectral absorption band seen in diffuse reflectance at 2.2-2.3 μm in spectra we have obtained of several D-type asteroids, and in published spectra of two "new" comets, the dark hemisphere of Iapetus, and the rings of Uranus. This band is the first overtone of the -C≡N fundamental at wavelengths between 4.5 and 4.8 μm, depending on the chemical environment of the group. This work suggests that those objects bearing the -C≡N signature have not been altered by liquid water, indicating either the absence of water or a thermal history in which water was never in a liquid or vapor phase. By implication, the surface materials of the D-type asteroids are the least chemically altered material in the middle regions of the Solar System.

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